INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

ELECTRICALAND ELECTRONICS ENGINEERING

COURSE DESCRIPTOR

Course Title	**LINEAR ALGEBRA AND CALCULUS**				
Course Code	AHSB02				
Programme	B. Tech				
Semester	I	AE | CSE | IT | ECE | EEE | ME | CE			
Course Type	Foundation				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	**Ms. P Rajani, Assistant Professor**				
Course Faculty	**Dr. M Anita, Professor** **Dr. S Jagadha, Professor** **Dr. J Suresh Goud, Assistant Professor** **Ms. L Indira, Assistant Professor** **Mr. Ch Somashekar, Assistant Professor** **Ms. P Srilatha, Assistant Professor** **Ms. C Rachana, Assistant Professor** **Ms. V Subba Laxmi, Assistant Professor** **Ms. B Praveena, Assistant Professor**				

I. COURSE OVERVIEW:

The course focuses on more advanced Engineering Mathematics topics which provide with the relevant mathematical tools required in the analysis of problems in engineering and scientific professions. The course includes types of Matrices and its applications, maxima and minima of functions of several variables, solutions of higher order ordinary differential equations, multiple integrals and vector calculus. The mathematical skills derived from this course form a necessary base to analytical and design concepts encountered in the program.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	Basic Principles of Algebra and Calculus

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Linear Algebra and Calculus	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✔	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✘	Mini Project	✔	Videos
✘	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	**Theory**			**Total Marks**
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning centre. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Presentation on real-world problems
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Seminar
PO 4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Term Paper

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	Able to utilize the knowledge of high voltage engineering in collaboration with power systems in innovative, dynamic and challenging environment, for the research based team work.	1	Seminar
PSO 2	To explore the scientific theories, ideas, methodologies and the new cutting edge technologies in renewable energy engineering, and use this erudition in their professional development and gain sufficient competence to solve the current and future energy problems universally.	-	-
PSO 3	To be able to utilize of technologies like PLC, PMC, process controllers, transducers and HMI and design, install, test , maintain power systems and industrial applications.	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Determine rank of a matrix and solve linear differential equations of second order.
II	Determine the characteristic roots and apply double integrals to evaluate area.
III	Apply mean value theorems and apply triple integrals to evaluate volume.
IV	Determine the functional dependence and extremum value of a function.
V	Analyze gradient, divergence, curl and evaluate line, surface, volume integrals over a vector field.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Determine rank by reducing the matrix to Echelon and Normal forms. Determine inverse of the matrix by Gauss Jordon Method and Solving Second and higher order differential equations with constant coefficients.	CLO 1	Demonstrate knowledge of matrix calculation as an elegant and powerful mathematical language in connection with rank of a matrix.
		CLO 2	Determine rank by reducing the matrix to Echelon and Normal forms.
		CLO 3	Determine inverse of the matrix by Gauss Jordon Method.
		CLO 4	Find the complete solution of a non-homogeneous differential equation as a linear combination of the complementary function and a particular solution.
		CLO 5	Solving Second and higher order differential equations with constant coefficients.

COs	Course Outcome	CLOs	Course Learning Outcome
CO 2	Determine a modal matrix, and reducing a matrix to diagonal form. Evaluate inverse and powers of matrices by using Cayley-Hamilton theorem. Evaluate double integral. Utilize the concept of change order of integration and change of variables to evaluate double integrals. Determine the area.	CLO 6	Interpret the Eigen values and Eigen vectors of matrix for a linear transformation and use properties of Eigen values
		CLO 7	Understand the concept of Eigen values in real-world problems of control field where they are pole of closed loop system.
		CLO 8	Apply the concept of Eigen values in real-world problems of mechanical systems where Eigen values are natural frequency and mode shape.
		CLO 9	Use the system of linear equations and matrix to determine the dependency and independency.
		CLO 10	Determine a modal matrix, and reducing a matrix to diagonal form.
		CLO 11	Evaluate inverse and powers of matrices by using Cayley-Hamilton theorem.
		CLO 12	Apply double integrals to evaluate area of a given function.
		CLO 13	Utilize the concept of change order of integration and change of variables to evaluate double integrals.
CO 3	Apply the Mean value theorems for the single variable functions. Apply triple integrals to evaluate volume.	CLO 14	Apply the Mean value theorems for the single variable functions.
		CLO 15	Apply triple integrals to evaluate volume of a given function.
CO 4	Determine the maxima and minima for a function of several variable with and without constraints.	CLO 16	Find partial derivatives numerically and symbolically and use them to analyze and interpret the way a function varies.
		CLO 17	Understand the techniques of multidimensional change of variables to transform the coordinates by utilizing the Jacobian. Determine Jacobian for the coordinate transformation.
		CLO 18	Apply maxima and minima for functions of several variable's and Lagrange's method of multipliers.
CO 5	Analyze scalar and vector fields and compute the gradient, divergence and curl. Evaluate line, surface and volume integral of vectors. Use Vector integral theorems to facilitate vector integration.	CLO 19	Analyze scalar and vector fields and compute the gradient, divergence and curl.
		CLO 20	Understand integration of vector function with given initial conditions.
		CLO 21	Evaluate line, surface and volume integral of vectors.
		CLO 22	Use Vector integral theorems to facilitate vector integration.

X. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AHSB02.01	CLO 1	Demonstrate knowledge of matrix calculation as an elegant and powerful mathematical language in connection with rank of a matrix	PO 1	3
AHSB02.02	CLO 2	Determine rank by reducing the matrix to Echelon and Normal forms.	PO 1 PO 2	3

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AHSB02.03	CLO 3	Determine inverse of the matrix by Gauss Jordon Method.	PO 1	3
AHSB02.04	CLO 4	Find the complete solution of a non-homogeneous differential equation as a linear combination of the complementary function and a particular solution.	PO 1 PO 2	3
AHSB02.05	CLO 5	Solving Second and higher order differential equations with constant coefficients.	PO 1 PO 2	3
AHSB02.06	CLO 6	Interpret the Eigen values and Eigen vectors of matrix for a linear transformation and use properties of Eigen values	PO 1	2
AHSB02.07	CLO 7	Understand the concept of Eigen values in real-world problems of control field where they are pole of closed loop system.	PO 4	1
AHSB02.08	CLO 8	Apply the concept of Eigen values in real-world problems of mechanical systems where Eigen values are natural frequency and mode shape.	PO 4	1
AHSB02.09	CLO 9	Use the system of linear equations and matrix to determine the dependency and independency.	PO 1	1
AHSB02.10	CLO 10	Determine a modal matrix, and reducing a matrix to diagonal form.	PO 1 PO2	3
AHSB02.11	CLO 11	Evaluate inverse and powers of matrices by using Cayley-Hamilton theorem.	PO 1	3
AHSB02.12	CLO 12	Apply double integrals to evaluate area of a given function.	PO 2	2
AHSB02.13	CLO 13	Utilize the concept of change order of integration and change of variables to evaluate double integrals.	PO 1 PO 2	3
AHSB02.14	CLO 14	Apply the Mean value theorems for the single variable functions.	PO 1	2
AHSB02.15	CLO 15	Apply triple integrals to evaluate volume of a given function.	PO 1	3
AHSB02.16	CLO 16	Find partial derivatives numerically and symbolically and use them to analyze and interpret the way a function varies.	PO 1 PO 2	3
AHSB02.17	CLO 17	Understand the techniques of multidimensional change of variables to transform the coordinates by utilizing the Jacobian. Determine Jacobian for the coordinate transformation.	PO 1 PO 2	3
AHSB02.18	CLO 18	Apply maxima and minima for functions of several variable's and Lagrange's method of multipliers.	PO 1 PO 2	3
AHSB02.19	CLO 19	Analyze scalar and vector fields and compute the gradient, divergence and curl.	PO 1 PO 2	3
AHSB02.20	CLO 20	Understand integration of vector function with given initial conditions.	PO 1 PO 2	3
AHSB02.21	CLO 21	Evaluate line, surface and volume integral of vectors.	PO 1	3
AHSB02.22	CLO 22	Use Vector integral theorems to facilitate vector integration.	PO 1	3

3= High; 2 = Medium; 1 = Low

XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

Course Outcomes (COs)	Program Outcomes (POs)			
	PO 1	PO 2	PO 4	PSO1
CO 1	3	2		1
CO 2		2	1	
CO 3	3	2		1
CO 4	3	2		1
CO 5	3	2		

XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	3												1		
CLO 2	3	2													
CLO 3	3														
CLO 4	3	2											1		
CLO 5	3	2													
CLO 6	3														
CLO 7				1											
CLO 8				1											
CLO 9	3												1		
CLO 10	3	2													
CLO 11	3														
CLO 12	3	2											1		
CLO 13	3	2													
CLO 14	2												1		
CLO 15	3														
CLO 16	3	2											1		
CLO 17	2	2											1		
CLO 18	3	2											1		

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 19	3	2											1		
CLO 20	3	1											1		
CLO21	2														
CLO22	3												1		

3 = High; 2 = Medium; 1 = Low

XIII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO4,PSO1	SEE Exams	PO1, PO2, PO4,PSO1	Assignments	-	Seminars	PO1, PO2, PO4,PSO1
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO1, PO2, PO4,PSO1						

XIV. ASSESSMENT METHODOLOGIES - INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XV. SYLLABUS

Module-I	**THEORY OF MATRICES AND HIGHER ORDER LINEAR DIFFERENTIAL EQUATIONS**	**Classes: 09**
THEORY OF MATRICES: Real matrices: Symmetric, skew-symmetric and orthogonal matrices; Complex matrices: Hermitian, Skew-Hermitian and unitary matrices; Elementary row and column transformations; Rank of a matrix: Echelon form and normal form; Inverse by Gauss-Jordan method. **HIGHER ORDER LINEAR DIFFERENTIAL EQUATIONS:** Linear differential equations of second and higher order with constant coefficients, non-homogeneous term of the type $f(x)=e^{ax}, \sin ax, \cos ax$ and $f(x)=x^n, e^{ax}v(x), xv(x)$; Method of variation of parameters.		
Module-II	**LINEAR TRANSFORMATIONS AND DOUBLE INTEGRALS**	**Classes: 09**
LINEAR TRANSFORMATIONS: Cayley-Hamilton theorem: Statement, verification, finding inverse and powers of a matrix; Linear dependence and independence of vectors; Eigen values and Eigen vectors of a matrix and Properties (without proof); Diagonalization of matrix by linear transformation. **DOUBLE INTEGRALS:** Evaluation of double integrals in Cartesian coordinates and Polar coordinates; Change of order of integration; Area as a double integral; Transformation of coordinate system.		
Module-III	**FUNCTIONS OF SINGLE VARIABLES AND TRIPLE INTEGRALS**	**Classes: 09**
FUNCTIONS OF SINGLE VARIABLES: Mean value theorems: Rolle's theorem, Lagrange's theorem,		

Cauchy's theorem-without proof and geometrical interpretation. **TRIPLE INTEGRALS:** Evaluation of triple integrals in Cartesian coordinates; volume of a region using triple integration.

Module-IV	**FUNCTIONS OF SEVERAL VARIABLES AND EXTREMA OF A FUNCTION**	**Classes: 09**
FUNCTIONS OF SEVERAL VARIABLES: Partial differentiation, functional dependence, Jacobian. **EXTREMA OF A FUNCTION:** Maxima and minima of functions of two variables without constraints and with constraints; Method of Lagrange multipliers.		
Module-V	**VECTOR DIFFERENTIAL AND INTEGRAL CALCULUS**	**Classes: 09**
VECTOR DIFFERENTIAL CALCULUS: Scalar and vector point functions; Definitions of Gradient, divergent and curl with examples; Solenoidal and irrotational vector point functions; Scalar potential function. **VECTOR INTEGRAL THEOREMS**: Line integral, surface integral and volume integral, Green's theorem in a plane, Stoke's theorem and Gauss divergence theorem without proofs.		
Text Books:		
1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010. 2. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008. 3. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint 2010.		
Reference Books:		
1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006. 2. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008. 3. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005. 4. Dr. M Anita, Engineering Mathematics-I, Everest Publishing House, Pune, 1st Edition, 2016.		

XVI. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1	Define types of matrices.	CLO 1	T2:32.1 R1:4.1
2	Apply Elementary row and column transformation.	CLO 2	T2:32.1 R1:4.2
3	Determine the Rank of a matrix, by Echelon form and Normal form.	CLO 2	T2:32.1 R1:4.3
4	Apply Gauss Jordan method to find inverse.	CLO 3	T2:32.1 R1:4.3
5	Determine complementary function for homogeneous higher order linear differential equations.	CLO 4	T3-2.9 R1:2.1
6	Solving non-homogeneous higher order linear differential equations: methods of finding particular integral.	CLO 5	T3-2.5 R1:2.8
7	Determine particular non-homogeneous term of the type $f(x) = e^{ax}$	CLO 5	T3-2.5 R1:2.8
8	Determine particular non-homogeneous term of the type $f(x) = \sin ax, \cos ax$	CLO 5	T3-2.5 R1:2.8

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
9	Determine particular for non-homogeneous term of the type $f(x)=x^n$	CLO 5	T3-2.5 R1:2.8
10	Determine of finding particular for non-homogeneous term of the type $f(x)=e^{ax}v(x)$	CLO 5	T3-2.5 R1:2.8
11	Determine of finding particular integral for non-homogeneous term of the type $f(x)=x^n v(x)$	CLO5	T3-2.5 R1:2.8
12	Solving second order linear differential equations using method of variation of parameters.	CLO 5	T3-2.61 R1:2.10
13	Apply Cayley-Hamilton theorem to find inverse of matrix.	CLO 11	T2:32.5 R1:4.6
14	Distinguish Linear dependency and independencey of vectors.	CLO 7	T2:32.5 R1:4.6
15	Define and find Eigen values and Eigen vectors.	CLO 6	T2:32.4 R1:4.5
16	Define and apply the properties of Eigen values and Eigen vectors.	CLO 6	T2:32.4 R1:4.5
17	Use diagonalisation to diagonalise a square matrix and find higher powers of a matrix.	CLO 10	T2:32.7 R1:4.8
18	Calculate double integrals of a function in Cartesian form.	CLO 12	T2:15.5 R1:7.5
19	Calculate double integral of a function in polar form.	CLO 12	T2-16.5 R1:7.6
20	Use the Change of order of integrations Cartesian and polar form.	CLO 13	T2-16.5 R1:7.6
21	Use the Change of order of integrations Cartesian and polar form.	CLO 13	T2-16.5 R1:7.6
22	Use transformation of coordinate system to evaluate double integral.	CLO 13	T2-16.5 R1:7.6
23	Apply the Rolle's theorem.	CLO 14	T2-7.1 R1:7.4
24	Apply Lagrange's Mean Value Theorem.	CLO 14	T2-7.1 R1:7.4
25	Apply Cauchy's Mean Value Theorem.	CLO 14	T2-7.1 R1:7.4
26	Calculate triple integrals in Cartesian form .	CLO 15	T2-11.1 R2:6.15
27	Apply triple integration for finding the volume.	CLO 15	T2-11.1 R2:6.16
28	Find partial derivatives.	CLO16	T3:4.10
29	Apply Jacobian transformation.	CLO17	T3:4.42
30	Apply Jacobian transformation.	CLO17	T3:4.42
31	Determine maximum and minimum of a function of several variables.	CLO18	T2:7.1 R1:7.4
32	Determine maximum and minimum of a function of several variables.	CLO18	T2:7.1 R1:7.4
33	Use the Lagrange multiplier method to find extreme of functions with constraints.	CLO18	T2:7.1 R1:7.4
34	Define vector calculus and vector fields and their properties.	CLO19	T2:11.1 R2:6.15
35	Determine Solenoidal and irrotational vector point function.	CLO20	T2:10.1 R1:16.1

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
36	Determine Scalar potential function.	CLO20	T2:10.1 R1:16.2
37	Calculate line integral along smooth path and find work done.	CLO21	T2:10.3 R1:16.4
38	Calculate the surface area of field.	CLO21	T2:11.3 R1:16.5
39	Calculate volume of field.	CLO21	T2:11.3 R1:16.5
40	Use Green's theorem to evaluate line integrals along simple closed contours on the plane.	CLO22	T2:11.3 R1:16.5
41	Use Green's theorem to evaluate line integrals along simple closed contours on the plane.	CLO22	T2:11.3 R1:16.5
42	Use the divergence theorem to give a physical interpretation of the divergence of a vector field.	CLO22	T2: 11.4
43	Use the divergence theorem to give a physical interpretation of the divergence of a vector field.	CLO22	R1:16.8
44	Use Stokes' theorem to give a physical interpretation of the curl of a vector field.	CLO22	T2: 11.3 R1:16.9
45	Use Stokes' theorem to give a physical interpretation of the curl of a vector field.	CLO22	T2: 11.3 R1:16.19

XVII. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S No	Description	Proposed Actions	Relevance With POs	Relevance With PSOs
1	Matrices and its applications, applications of maxima and minima of functions of single and several variable.	Seminars	PO 1	PSO 1
2	Change of order of integration, geometrical interpretation of vector integral theorems and properties of gamma and Bessel differential equation.	Seminars / NPTEL	PO 2	PSO 1
3	Encourage students to solve real time applications and prepare towards competitive examinations.	NPTEL	PO 2	PSO 1

Prepared by:
Ms. P Rajani, Assistant Professor **HOD, EEE**